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| **Lesson Title:**  **VIVID VOLUME**  **Volume Measurement of Common Geometric Solids** |
| **Subject area / course / grade level:**  **Geometry & Measurement / Math / Grades 5 – 6** |
| **Introduction:**  This lesson is designed to focus on a major content topic in the measurement curriculum – understanding how volume formulas are derived for common geometric solids, like prisms, pyramids, cylinders, and cones. Elementary students generally encounter solids very early on and study these shapes throughout their school grades. In particular, they are frequently introduced to common measurement formulas by mere presentation and often have to resort to memorizing them without fully understanding the general patterns supporting the formulas’ development. Memorization alone rarely allows for easy use or application of the measurement formulas within varied problem solving contexts. Thus, because students’ constructive knowledge of how these formulas are derived is limited, their ability to apply and/or recall the formulas may be limited as well. |
| **Lesson Length:**  **45 – 60 min** |
| **Materials:**    **Allow students to work in small groups (2 – 4 students). Each group needs:**   * Set of clear geometric solids – including various prisms, pyramids, cylinders, & cones– with removable faces * Bag of dry rice per small group (or small pebbles, water) (*Suggestion:* Teachers may want to pool their resources to purchase a large quantity of rice, or see your Cafeteria Manager for some “free” rice. Fill individual gallon Ziploc bags with enough rice for each group.) * Handout of Sample Exercises * Math Notebooks * Paper and pencils * Butcher paper (for excess rice and easy clean-up in each group) |
| **Lesson Overview:**  (Per teacher directions and grouping):  Students should begin this lesson by sorting the geometric solids into like (size/shape) categories (prisms, pyramids, cylinders, and cones). Brief discussion should occur as to when students encounter these type shapes in real-life settings (e.g., buildings, cereal boxes, coke cans). Also, students can brainstorm various objects which we see and/or use every day demonstrating the concept of volume. Groups should record their data and then focus on two major comparisons that will form the major parts of the Lesson:  **PART 1: Compare the Prism and the Pyramid**   * Have students select a prism and a pyramid which have the **same size base and same height** (This is a critical requirement for the two shapes; otherwise the students will be comparing “apples & oranges” and the volume relationship between the two shapes will not be visible). * Present the question: *How many pyramid cups of rice are needed to fill a prism exactly?* Have students pose various estimates. Briefly discuss. (Expect responses like 2, 2½, 3, …) * Demonstrate in front of the class the number of pyramids it takes to fill the prism. Be as exact as possible; fill the prism one pyramid cup at a time to the notched edge. It should take exactly 3 pyramid cups to fill the prism given the shapes have the **same size base and same height**. * Discuss with students the results. After all reach agreement, have them complete the sentence:   *It takes \_\_\_\_ pyramid cups to fill the prism.* Allow students to reflect on their estimations compared to the actual number, and record their data/conclusions.   * Shift to discuss the volume of the prism, **V=*Bh***, where ***B* = Area of the Base** (either one of the parallel faces) and ***h* = height** (distance between the two bases). Note: some textbooks might state this volume formula as   **V= *lwh***. If so, recognize that ***B*=*lw***.  (Demonstrating the volume of the prism can be done in a variety of ways. Consider this example: use multi-link cubes and stack layers on top of each other creating a prism. See that volume is determined by multiplying the area of each layer (***lw***) by the number of layers in the stack (***h***).)   * Given the previous rice-filling demonstration, have students determine the volume of the pyramid, **V=*Bh*.**   That is, because it took 3 pyramids cups to completely fill the prism, the volume of the pyramid is then one-third that of the prism – again, given that the two shapes share the same size base and same height.   * **See Sample Practice Exercises:** * Debrief with students what they learned by having them write a brief summary on the board using results from the demonstration and their group work. Encourage students to use appropriate vocabulary. Add new vocabulary and formulas to a word wall.   **PART 2: Repeat PART 1 above comparing the Cylinder and the Cone**   * Have students select a cylinder and a cone which have the **same size base and same height** (For the same reasons as above, this is a critical requirement for the two shapes.) * Present the question: *How many cones of rice are needed to fill a cylinder exactly?* Have students pose various estimates. Briefly discuss. (Expect responses like 2, 2½, 3, …) * Demonstrate in front of the class the number of cones it takes to fill the cylinder. Be as exact as possible; fill the cylinder one cone at a time to the notched edge. It should take exactly 3 cones to fill the cylinder. * Discuss with students the results. After all reach agreement, have them complete the sentence:   *It takes \_\_\_\_ cones to fill the cylinder.* Allow students to reflect on their estimations compared to the actual number, and record their data/conclusions.   * Shift to discuss the volume of the cylinder, **V*=*π*r2h***, where **π*r2* = Area of the Circular Base** (either one of the circular faces) and ***h* = height** (distance between the two bases). Note: some textbooks might refer to a cylinder as a “circular prism” and thus might state this volume formula more generally as **V= *Bh,*** like that in PART 1 above. If so, recognize that ***B*=π*r2*** and therefore the general formula is correct as well.   (Demonstrating the volume of the cylinder can be done in a variety of ways. Consider this example: a set of eight circular cup-holders are stacked creating a cylinder model. See that volume is determined by multiplying the area of each cup-holder (**π*r2***) by the number of layers in the stack (***h***) in this case, 8.)   * Given the previous rice-filling demonstration, have students determine the volume of the cone, **V = π*r2h*,** or   **V =*Bh***.That is, because it took 3 cones to completely fill the cylinder, the volume of the cone is then one-third that of the cylinder – again, given that the two shapes share the same size base and same height.   * **See Sample Practice Exercises:** * Debrief with students what they learned by having them write a brief summary on the board using results from the demonstration and their group work. Encourage students to use appropriate vocabulary. Add new vocabulary and formulas to a word wall. |
| **Tennessee Standards:**  GLE 0406.4.2 – Understand and use measures of length, area, capacity, and weight.  GLE 0406.4.3 – Solve problems that involve estimating and measuring length, area, capacity and weight.  GLE 0506.4.1 – Use basic formulas and visualization to find the area of geometric figures.  GLE 0506.4.2 – Describe polyhedral solids and analyze their properties, including volume and surface area.  GLE 0506.5.1 – Make record, display and interpret data and graphs that include whole numbers, decimals, and fractions.    GLE 0606.4.3 – Develop and use formulas to determine the circumference and area of circles, and the area of  trapezoids, and develop strategies to find the area of composite shapes.  GLE 0606.4.4 – Develop and use formulas for surface area and volume of 3-dimensional figures.  GLE 0606.1.8 – Use technologies/manipulatives appropriately to develop understanding of mathematical algorithms, to  facilitate problem solving, and to create accurate and reliable models of mathematical concepts.  **MCS/Math Power Standards:**  Grade 4 - Understand and use measures of length, area, capacity and weight.  Grade 5 - Find the area, volume and surface area of geometric figures including irregular shapes, prisms and  polyhedral solids.  Grade 6 - Develop and use formulas to determine the circumference and areas of circles and the area of  trapezoids and develop strategies to find the area of composite shapes.  -Determine surface area and volume of prisms, pyramids and cylinders. |
| **Lesson objective(s):**  **TLW:** Demonstrate appropriate understanding of vocabulary terms used to calculate volume.  Develop and apply content knowledge of how volume formulas are derived for common 3-D geometric shapes. |
| **ENGAGEMENT**   * Describe how the teacher will capture students’ interest. * What kind of questions should the students ask themselves after the engagement?   **Activity:**  Give each group a box of Animal Crackers, popcorn or etc.  Prompt a discussion based on questions like: *What can we do with this box mathematically?* *What shape is the box? How do you calculate the volume of the box?* Etc.  **More Questions**:  1. What is the Volume of the box?  2. How is calculating volume used in real-life settings?  3. Why is understanding how to calculate volume important? |
| **EXPLORATION**   * Describe what hands-on/minds-on activities students will be doing. * List “big idea” conceptual questions the teacher will use to encourage and/or focus students’ exploration   **Hands-on/Minds-on Activities:**    *Refer to PART 1 and PART 2 of Lesson Overview for Activities.*  **Big-Idea Questions include:**  What are the formulas for calculating volume?  How is calculating volume used in real-life settings?  Why is understanding how to calculate volume important? |
| **EXPLANATION**   * Student explanations should precede introduction of terms or explanations by the teacher. What questions or techniques will the teacher use to help students connect their exploration to the concept under examination? * List higher order thinking questions which teachers will use to solicit *student* explanations and help them to justify their explanations.   **Questions:**  How is calculating volume used in real-life settings?  Why is understanding how to calculate volume important?  How would you explain the formulas to a classmate and/or family member? Try it. |
| **ELABORATION**   * Describe how students will develop a more sophisticated understanding of the concept. * What vocabulary will be introduced and how will it connect to students’ observations? * How is this knowledge applied in our daily lives?   **Additional Option:**  Teacher may choose to share *The Volume Video* to reinforce/enhance students’ knowledge. See website for  info: <http://www.havefunteaching.com/educational-videos/math/volume-video>   * Have students choose an object in classroom/at home which he/she will apply one of the formulas. * Reflect on all the different aspects of the formula and explain your findings to a classmate or your family.   **Vocabulary:**  polygons, volume, symbol, pi, rectangular prism, dimension, pyramid, prism, cone, cylinder, cubic units, capacity, compare, composite shape, calculate |
| **EVALUATION**   * How will students demonstrate that they have achieved the lesson objective? * This should be embedded throughout the lesson as well as at the end of the lesson * Sample exercises * Teacher/student observations * On-going discussions * Students’ recorded data |

**NOTES:**